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MATERIALS RESEARCH & ENGINEERING DIVISION

MATERIAL EXAMINATION REPORT

MER Report No.
8868

Date Reported:
September 1987

TITLE: Interim Report on Contract for Further Investigation of the Application of Permethrin to Battle Dress Uniforms (BDUs)

Prepared by:
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PURPOSE: To develop practical methods of application of a new arthropod repellent, Permethrin, to BDUs. The applications involved both the 100% cotton ripstop and 50/50 nylon/cotton materials used in the Hot Weather and Temperate BDUs.

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Background:

a. Reference Material Examination Report No. 8820 dated 10 October 1985.

b. Reference Material Examination Report No. 8853, dated 20 January 1987.

c. Reference Contract for Further Investigation of the Application of Permethrin to BDUs, dated 13 May 1987.

d. In referenced report a. above, five (5) methods of application of Permethrin were investigated. Field Laundry, Hot Dye Batch, and Aerosol Spray Application methods were excluded from further investigation. The Dynamic Absorption and Pad Roll Application methods were recommended for further investigation.

e. In referenced report b. above, the Individual Dynamic Absorption Application (IDAA) method was further investigated. During the course of the investigation several major changes in the work content of the project were requested by COL John F. Reinert, Insect/Arthropod Repellent Product Officer, U. S. Army Medical Materiel Development Activity, Ft. Detrick, Frederick, MD. The expanded work content included:

1. Reimpregnation and extensive laundering trials.

2. Investigation of the Aerosol Can Spray Application method.

3. Investigation of the Two-Gallon Field Sprayer Application method.

4. Further evaluation of the Pad Roll Application method.

Results of the investigations into all of the above, except the Two-Gallon Field Sprayer Application method, were detailed in the referenced report b.

f. In referenced contract c. above, five (5) areas of investigation were pin-pointed for investigation.

1. Minimum-Maximum range of Permethrin Application.
2. 32-Gallon Field Can Application method.
3. Extended investigation of the Aerosol Can Spray Application method.
4. Application of Permethrin from an organic solvent system.
5. Application and removal of Permethrin by the Laundry and Decontamination Drycleaning System (LADDS).

This interim report will cover the results of:

1. The Two-Gallon Field Sprayer Application.
2 The Min-Max Range of Permethrin Application.
3. The Development of the Individual Dynamic Absorption Application (IDAA) Kit.

The 32-Gallon, Extended Aerosol Can Spray, Application of Permethrin from an Organic Solvent System, and LADDS/Permethrin trials have yet to be completed.

CONCLUSIONS:

a. Two-Gallon Field Sprayer Application Method.

Although application by this method is simple and can be very accurate if applied properly, it is dubious whether the precise application time and pressure level necessary can be practically realized in the field. Further, it would be required that a sophisticated two-gallon sprayer be issued at company or battalion level and reserved exclusively for the application of Permethrin.

b. Min-Max Range of Permethrin Application

Extensive GC analyses of five different target levels point to 0.125 mg/sq cm as the optimum level. Efficacy of the Permethrin can probably be expected to continue through the 40-50 wash level.

c. Development of the Individual Dynamic Absorption Application Kit

Field trials of the IDAA kit were termed highly successful. With several minor modifications the kit will be recommended to an In-Process Review (IPR) Board #3 for adoption into the U.S. Army supply system.

SAMPLE DESCRIPTION:

Fabrics and BDUs used in the trials conformed to the following fabric specifications.

a. MIL-C-43468D, 21 May 1984, Cloth, Camouflage Pattern, Wind Resistant Cotton, Type III.

b. MIL-C-44031B, 17 February 1984, Cloth, Camouflage Pattern, Woodland, Nylon/Cotton, Class I.

PROCEDURE:

Laboratory formulations were developed and pilot plant applications performed on BDUs by the two (2) application methods listed below.

a. Two-Gallon Field Sprayer Application Method.

One hundred fifty-one (151) mls of Permanone were added to two (2) gallons of water in a field sprayer. Two BDU each of 100% cotton ripstop and Nyco were treated in the trial. Each BDU was placed on the ground and sprayed for 50 seconds @ 55 psi on each side. Launderings cycles of 1, 5, 10. and 25 were performed Samples for Gas Chromatographical (GC) analyses were drawn from the front and back, both coat and trousers.

b. Min-Max Range of Permethrin Application

Two-yard cuts of both BDU fabrics were impregnated with Permethrin by the IDAA method at target dosages of 0.015, 0.030, 0.063, 0.125, and 0.25 mg/cm sq. Launderings of 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 cycles were performed on the fabrics at each target dosage. After impregnation the BDUS were hung for air drying. Three hundred thirty (330) combined samples for GC and Bioassay analyses were taken from the fabric cuts.

c. Development of the Individual Dynamic Absorption Application Kit

Based on pilot plant work completed in the development of the IDAA method of impregnating BDUs, a five component prototype kit was developed for field trials. The components were:

1. Two treatment bags with zip-lock closures, one for the coat and one for the trousers.
2. Two ampules, each containing 9 ml of Permanone, one for the coat and one for the trousers,(target dosage for the kit was 0.125 mg/cm sq.)
3. Two common store-twine type strings approximately 24 inches long.
4. One Illustrated Instruction Sheet.
5. Printed inserts as required by The Enviormental Protection Agency.

d. Laundering Procedure

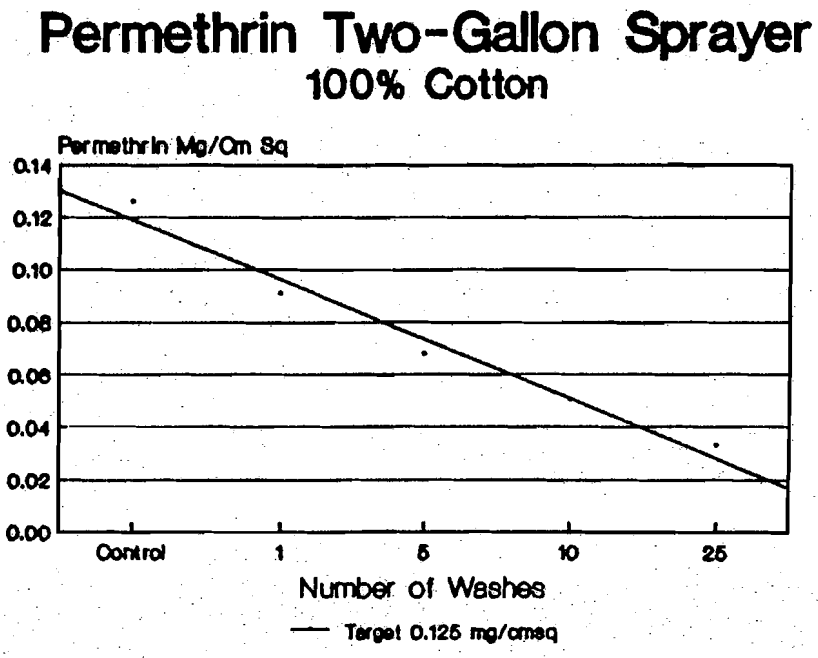
A standard U.S. Army Field Laundry was used for the laundering trials. The laundry unit consisted of a Pellerin Milnor Corp washer, Bock extractor, and York Shiply dryer. Each laundering cycle consisted of wash, extract, and dry. F-D-245, Type II detergent was used throughout.

RESULTS AND DISCUSSION:

a. Two-Gallon Field Sprayer Application Method

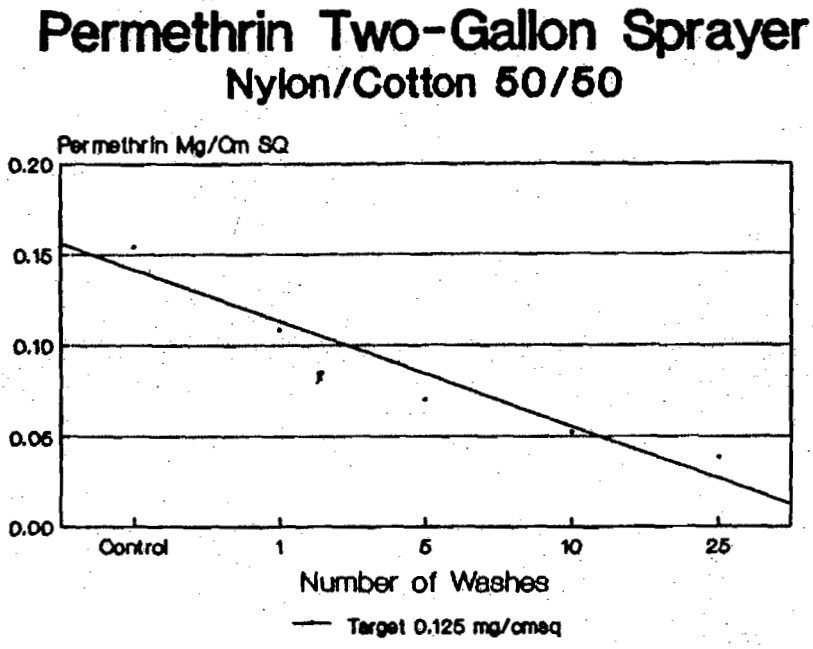
Following are the GC results. Mean values are based on a minimum of four (4) determinations of the treated uniforms.

1. 100% Cotton, Hot Weather BDU, 0.125 Mg/cm sq target level.



Sample	Mean	±	Standard Deviation	Mg/Sq Cm
Control	0.126	±	0.015	
1 wash	0.091	±	0.008	
5 Washes	0.068	±	0.007	
10 Washes	0.050	±	0.006	
25 Washes	0.033	±	0.003	

2. Nylon/Cotton, Temperate BDU, 0.125 Mg/sq cm target level.



Sample	Mean ± Standard Deviation	Mg/Sq Cm
Control	0.154 ± 0.028	
1 Wash	0.108 ± 0.007	
5 Washes	0.070 ± 0.009	
10 Washes	0.052 ± 0.010	
25 Washes	0.038 ± 0.004	

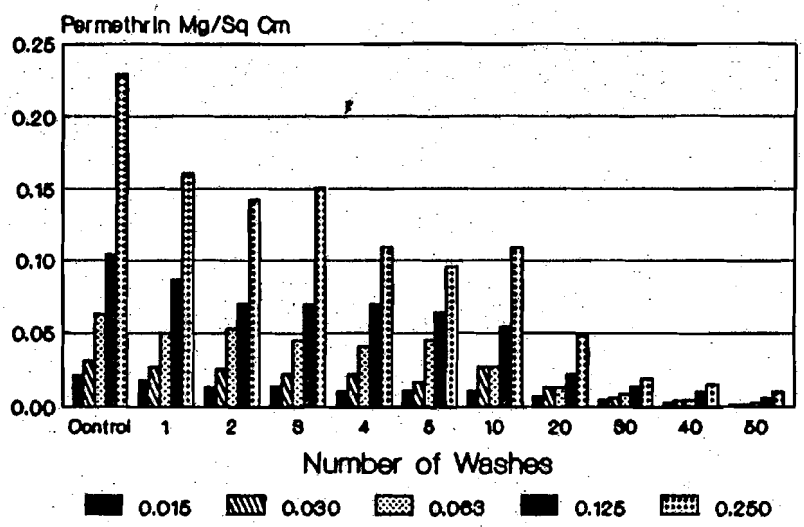
The results of the Two-Gallon Field Sprayer Application show reasonable closeness to target level with an acceptable standard deviation. The main concern is to duplicate such results in a practical manner in the field. Under PROCEDURES paragraph a, above, it was pointed out that application was made on each side of the BDUs for 50 seconds @55 psi. Is it reasonable to assume that troopers charged with the application will have the patience or the equipment necessary to make an acceptable application?

Low pressure and/or short time will result in application below target level and a corresponding loss of efficacy. High pressure and/or excess time will result in application beyond the maximum level (0.125 mg/sq cm) approved by the Surgeon General.

b. Min-Max Range of Permethrin Application

Following are the GC results. Mean values are based on three (3) determinations of treated fabrics.

1. 100% Cotton, Hot Weather BDU fabric, 0.125 Mg/sq cm target level.



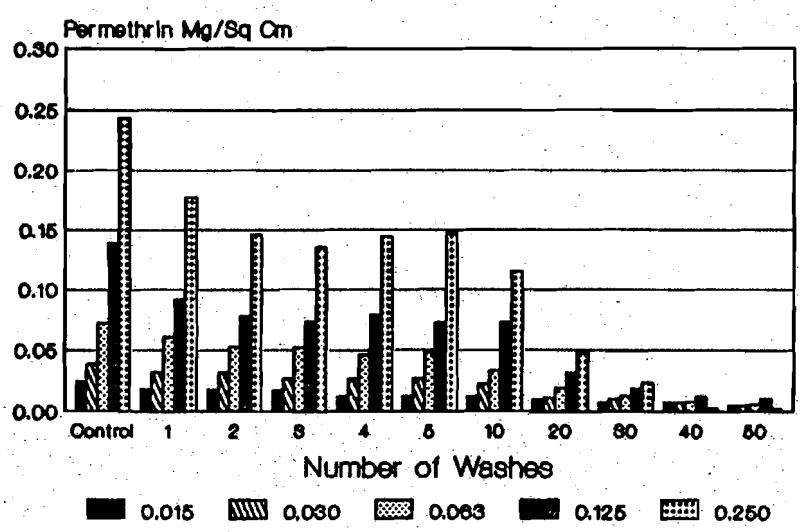
aerosol spr
can - 1 pass

Target Level - 0.015 mg/sq cm	- 0.030 mg/sq cm	- 0.063 mg/sq cm	.004mg/c
Control	0.021 ± 0.002	0.031 ± 0.005	0.063 ± 0.008	.003mg/c
1 Wash	0.018 ± 0.003	0.027 ± 0.004	0.050 ± 0.011	
2 Washes	0.013 ± 0.002	0.026 ± 0.003	0.053 ± 0.004	
3 Washes	0.014 ± 0.002	0.022 ± 0.002	0.045 ± 0.004	
4 Washes	0.011 ± 0.001	0.022 ± 0.001	0.041 ± 0.006	
5 Washes	0.011 ± 0.001	0.017 ± 0.001	0.045 ± 0.006	.007mg/c
10 Washes	0.011 ± 0.001	0.027 ± 0.004	0.027 ± 0.004	.006mg/c
20 Washes	0.007 ± 0.001	0.013 ± 0.001	0.013 ± 0.001 (15)	.004mg/c
30 Washes	0.005 ± 0.000	0.006 ± 0.001	0.009 ± 0.001 (25)	.003mg/c
40 Washes	0.003 ± 0.001	0.004 ± 0.000	0.005 ± 0.001	
50 Washes	0.002 ± 0.001	0.002 ± 0.001	0.003 ± 0.001	

Proposed Treatment Level

Target Level -	0.125 mg/sq cm	0.25 mg/sq cm
Control	0.104 ± 0.016	0.229 ± 0.012
1 Wash	0.087 ± 0.010	0.161 ± 0.008
2 Washes	0.070 ± 0.010	0.142 ± 0.018
3 Washes	0.070 ± 0.010	0.151 ± 0.007
4 Washes	0.070 ± 0.007	0.109 ± 0.005
5 Washes	0.064 ± 0.010	0.096 ± 0.004
10 Washes	0.054 ± 0.004	0.109 ± 0.004
20 Washes	0.022 ± 0.001	0.048 ± 0.010
30 Washes	0.014 ± 0.001	0.019 ± 0.000
40 Washes	0.010 ± 0.001	0.015 ± 0.002
50 Washes	0.006 ± 0.001	0.010 ± 0.001

2. Nylon/Cotton, Temperate BDU fabric, 0.125 Mg/sq cm target level.



Target Level - 0.015 mg/sq cm	- 0.030 mg/sq cm	- 0.063 mg/sq cm
Control	0.024 ± 0.002	0.038 ± 0.001	0.072 ± 0.004
1 Wash	0.018 ± 0.002	0.032 ± 0.002	0.061 ± 0.002
2 Washes	0.017 ± 0.000	0.031 ± 0.001	0.053 ± 0.001
3 Washes	0.017 ± 0.000	0.027 ± 0.001	0.052 ± 0.001
4 Washes	0.012 ± 0.001	0.027 ± 0.002	0.046 ± 0.003
5 Washes	0.012 ± 0.001	0.027 ± 0.002	0.048 ± 0.003
10 Washes	0.012 ± 0.001	0.022 ± 0.002	0.033 ± 0.002
20 Washes	0.009 ± 0.001	0.011 ± 0.001	0.019 ± 0.002
30 Washes	0.007 ± 0.001	0.010 ± 0.001	0.012 ± 0.001
40 Washes	0.007 ± 0.001	0.007 ± 0.001	0.008 ± 0.001
50 Washes	0.005 ± 0.001	0.005 ± 0.000	0.006 ± 0.000

Proposed Treatment Level

Target Level - 0.125 mg/sq cm	- 0.250 mg/sq cm
Control	0.139 ± 0.016	0.243 ± 0.057
1 Wash	0.092 ± 0.001	0.177 ± 0.025
2 Washes	0.078 ± 0.005	0.146 ± 0.004
3 Washes	0.073 ± 0.003	0.135 ± 0.001
4 Washes	0.079 ± 0.003	0.144 ± 0.007
5 Washes	0.072 ± 0.003	0.147 ± 0.009
10 Washes	0.073 ± 0.005	0.115 ± 0.006
20 Washes	0.031 ± 0.003	0.048 ± 0.005
30 Washes	0.018 ± 0.002	0.023 ± 0.002
40 Washes	0.012 ± 0.001	0.003 ± 0.001
50 Washes	0.010 ± 0.002	0.002 ± 0.001

3. The Permethrin appears to have been removed completely at the levels shown below.

   a. 100% Cotton
      1. 0.015 mg/sq cm target level - between 10 and 20 washes
      2. 0.030 and 0.063 mg/sq cm target levels - between 20 and 30 washes.
      3. 0.125 and 0.25 mg/sq cm target levels - between 40 and 50 washes.

   b. Nylon/Cotton 50/50
      1. 0.015, 0.030, and 0.063, 0.25 mg/sq cm target levels - between 30 and 40 washes
      2. 0.125 mg/sq cm after 50 washes.

4. It appears that 0.125 mg/sq cm is the optimum application level.

c. Development of the Individual Dynamic Absorption Application Kit

Approximately 110 troopers of the 214th Georgia National Guard volunteered for the field test of the IDAA kit at Ft Stewart, Georgia, August 8-22, 1987. Four kits were issued to each trooper. Three kits were for treatment of three BDUs owned by each trooper. The fourth kit was to be placed in the troopers pack for a durability test.

With a minimum of instructions the troopers were told to open the kits and proceed with treatment of the BDUs. After completion of all applications the BDUs were hung to dry inside a convenient barracks overnight. In the morning the BDUs were marked for treatment identification and returned to the owners.

Use of the IDAA kits went very smoothly. There were no complaints or negative comments from the volunteers about the kits. Each trooper treated six components, three BDU coats and three BDU trousers, with only minor problems, in an average time of only 20 minutes.

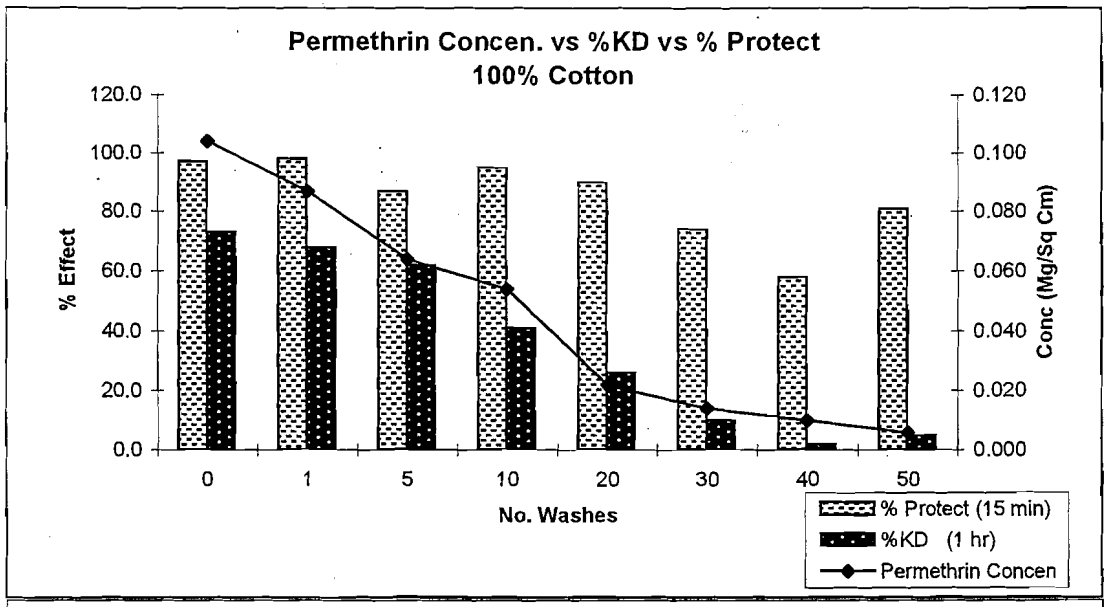
Permethrin Concentration vs % Knockdown vs % Protection

Anopheles albimanus

Anopheles albimanus

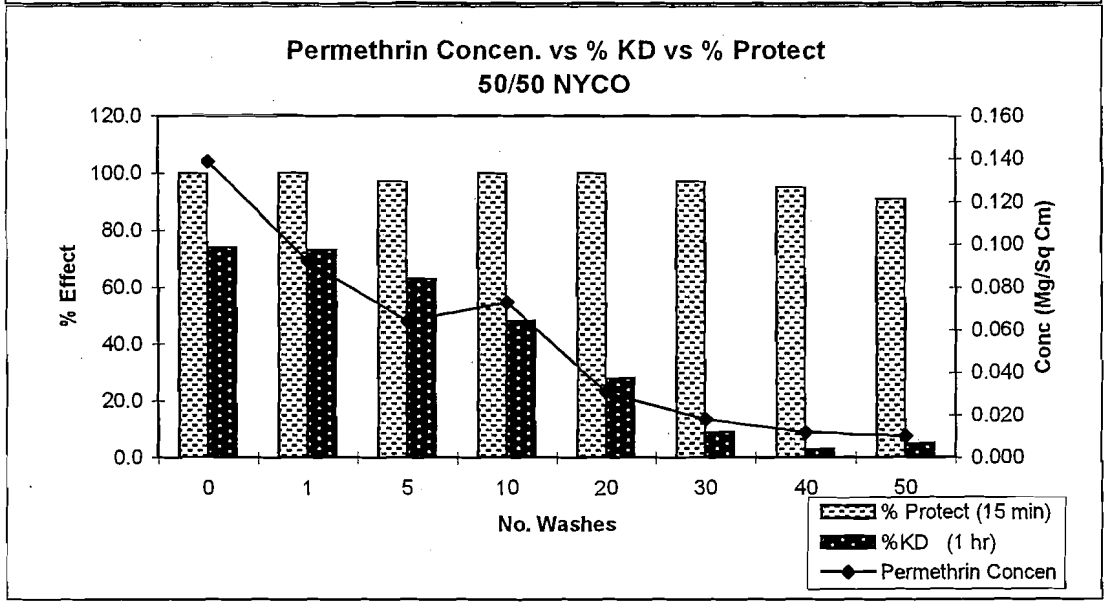
100% Cotton BDU

# Washes	% Protect (15 min)	%KD (1 hr)	Permethrin Concen (Mg/Sq Cm)
0	97.0	73.0	0.104
1	98.0	68.0	0.087
5	87.0	62.0	0.064
10	95.0	41.0	0.054
20	90.0	26.0	0.022
30	74.0	10.0	0.014
40	58.0	2.0	0.010
50	81.0	5.0	0.006



50/50 NYCO BDU

# Washes	% Protect (15 min)	%KD (1 hr)	Permethrin Concen (Mg/Sq Cm)
0	100.0	74.0	0.139
1	100.0	73.0	0.092
5	97.0	63.0	0.064
10	100.0	48.0	0.073
20	100.0	28.0	0.031
30	97.0	9.0	0.018
40	95.0	3.0	0.012
50	91.0	5.0	0.010



% Protect = % Protection from Bites

% KD = % Knockdown of Pest

NRDEC: MER 8868, Sep 87

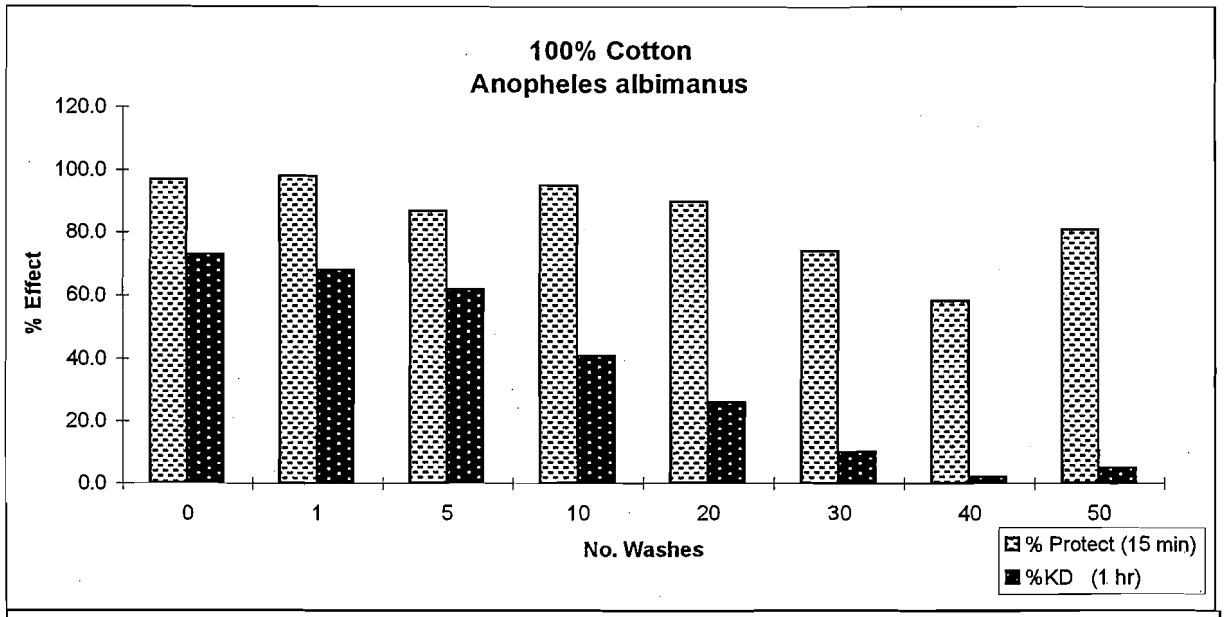
Mosquitoes: IDAA Kit Method

Permethrin at 0.125 mg/sq cm; 50 Washes

Anopheles albimanus

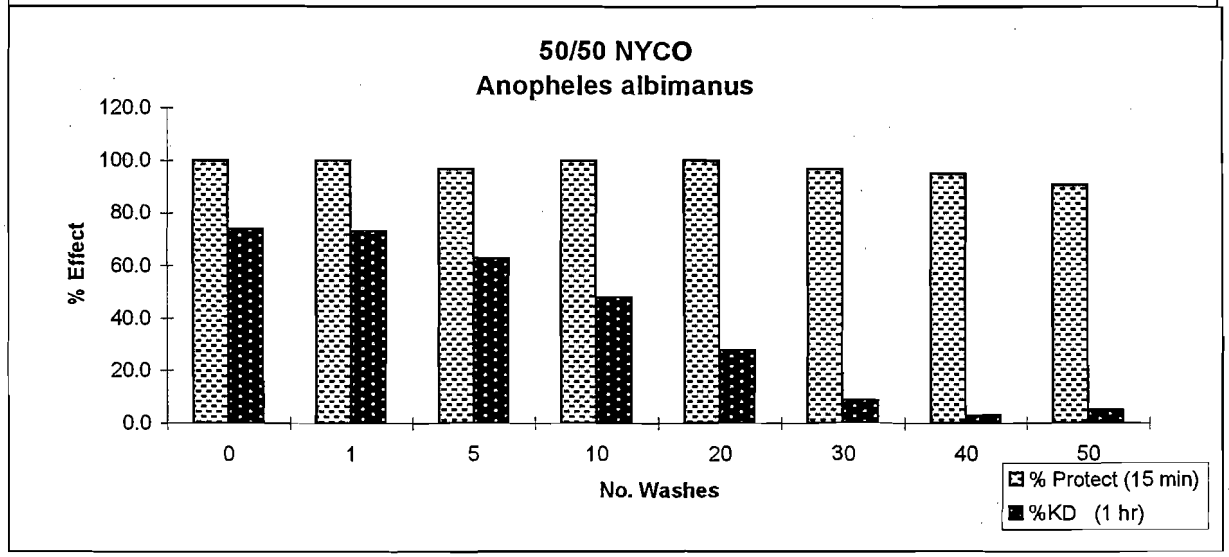
100% Cotton BDU

# Washes	% Protect (15 min)	%KD (1 hr)
0	97.0	73.0
1	98.0	68.0
5	87.0	62.0
10	95.0	41.0
20	90.0	26.0
30	74.0	10.0
40	58.0	2.0
50	81.0	5.0



50/50 NYCO BDU

# Washes	% Protect (15 min)	%KD (1 hr)
0	100.0	74.0
1	100.0	73.0
5	97.0	63.0
10	100.0	48.0
20	100.0	28.0
30	97.0	9.0
40	95.0	3.0
50	91.0	5.0



%Protect = % Protection from Bites

%KD = % Knockdown of Pest

NRDEC: MER 8868, Sep 87

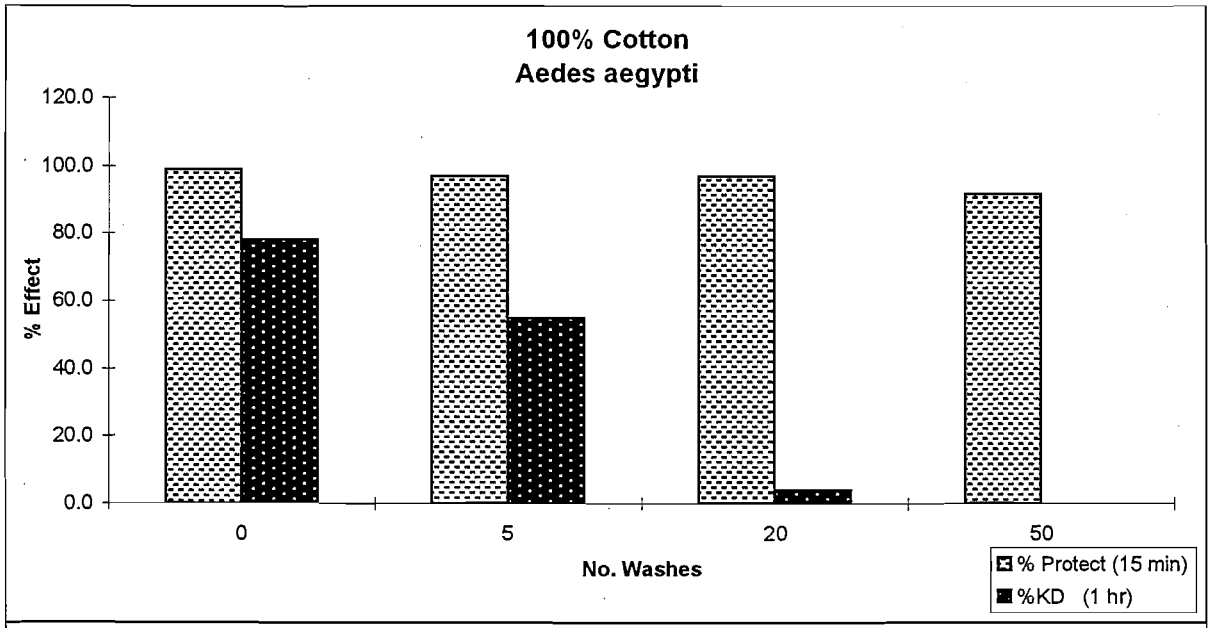
Mosquitoes: IDAA Kit Method

Permethrin at 0.125 mg/sq cm; 50 Washes

Aedes aegypti

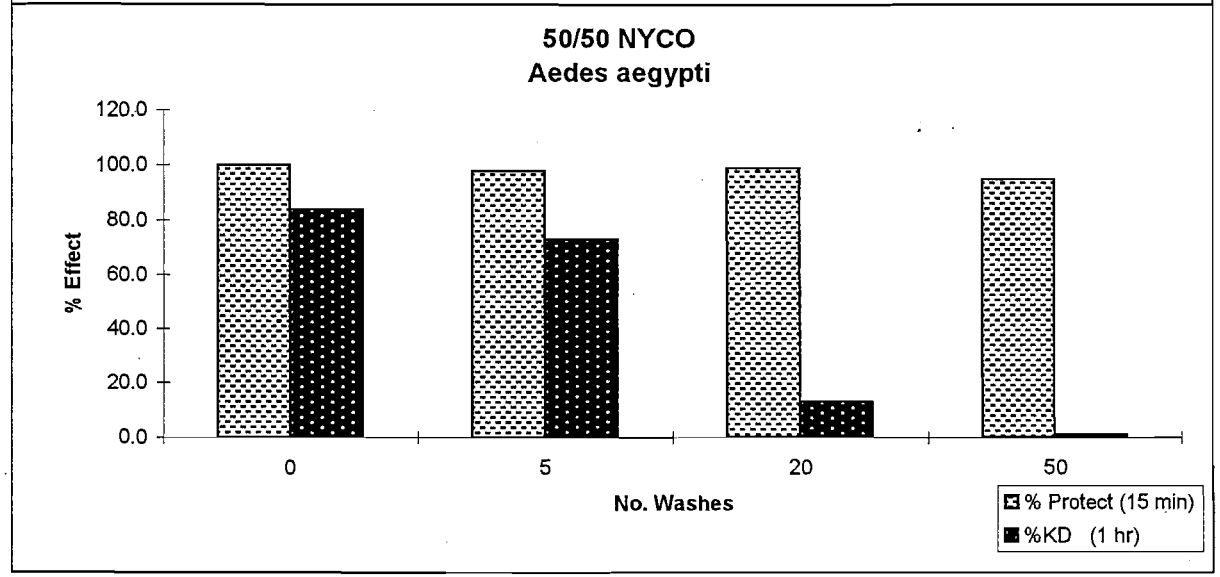
100% Cotton BDU

# Washes	% Protect (15 min)	%KD (1 hr)
0	99.0	78.0
5	97.0	55.0
20	97.0	4.0
50	92.0	0.0



50/50 NYCO BDU

# Washes	% Protect (15 min)	%KD (1 hr)
0	100.0	84.0
5	98.0	73.0
20	99.0	13.0
50	95.0	1.0



%Protect = % Protection from Bites

%KD = % Knockdown of Pest

NRDEC: MER 8868, Sep 87

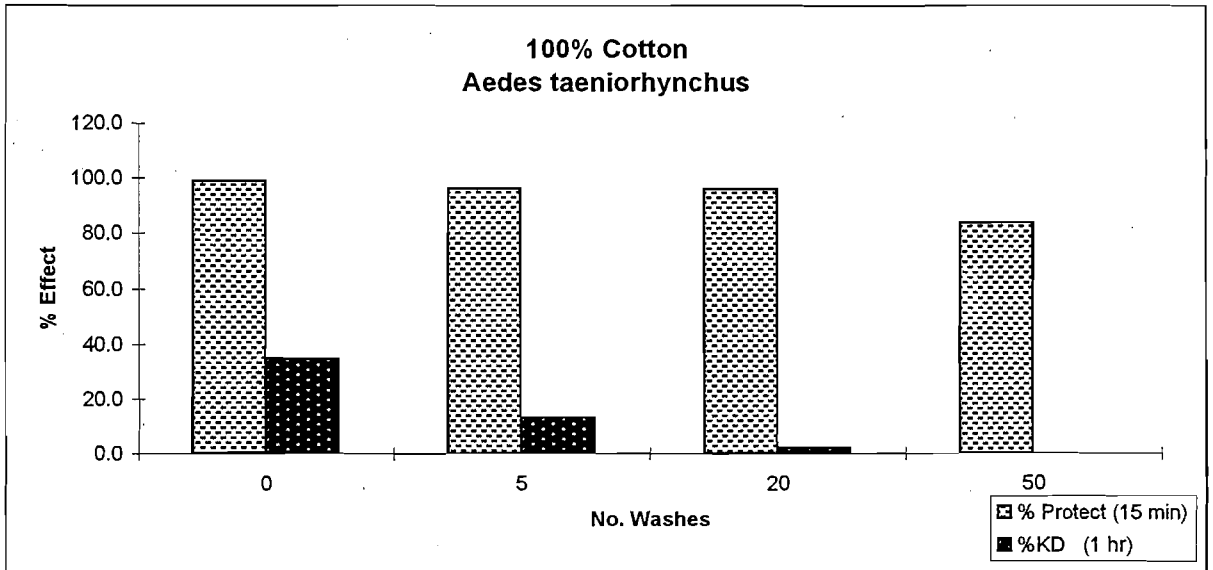
Mosquitoes: IDAA Kit Method

Permethrin at 0.125 mg/sq cm; 50 Washes

Aedes taeniorhynchus

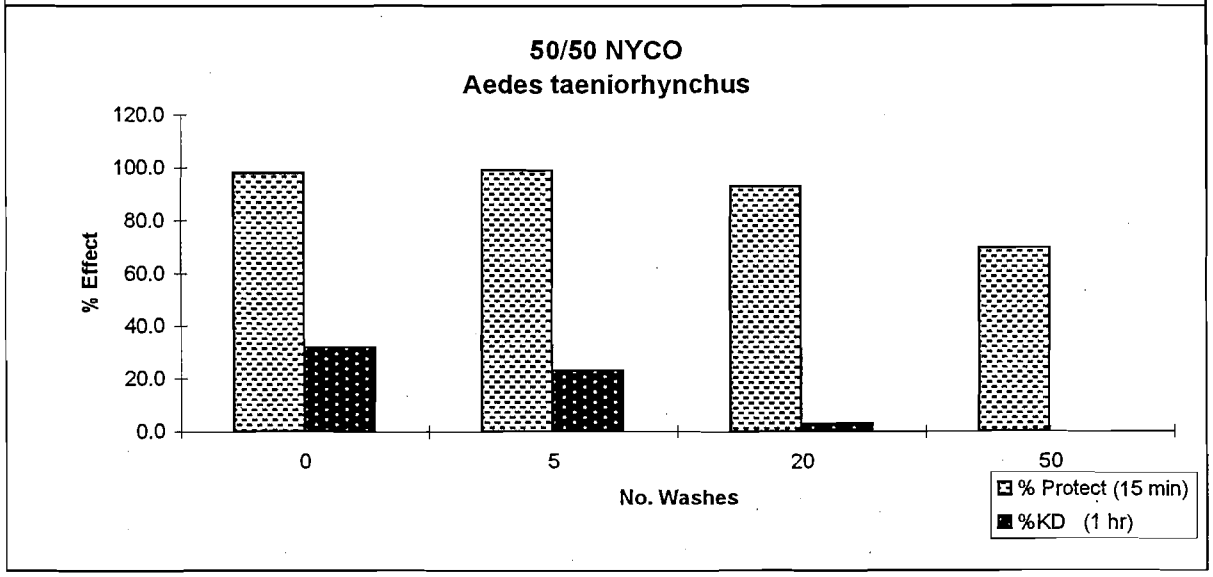
100% Cotton BDU

# Washes	% Protect (15 min)	%KD (1 hr)
0	99.0	35.0
5	96.0	13.0
20	96.0	2.0
50	84.0	0.0



50/50 NYCO BDU

# Washes	% Protect (15 min)	%KD (1 hr)
0	98.0	32.0
5	99.0	23.0
20	93.0	3.0
50	70.0	0.0



%Protect = % Protection from Bites

%KD = % Knockdown of Pest

NRDEC: MER 8868, Sep 87

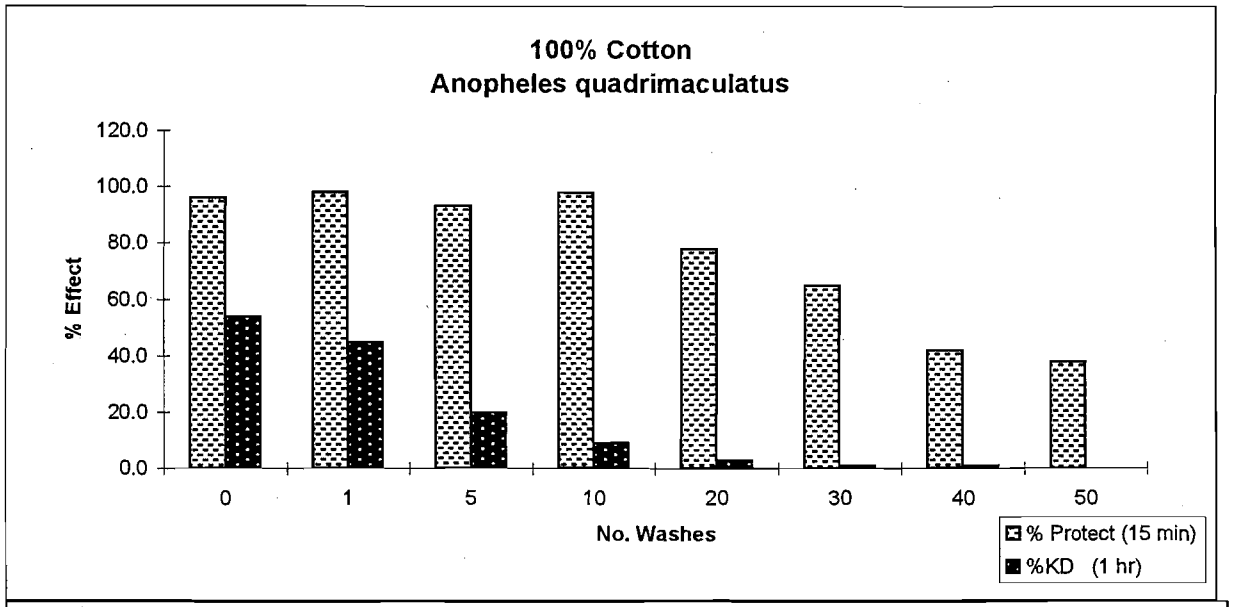
Mosquitoes: IDAA Kit Method

Permethrin at 0.125 mg/sq cm; 50 Washes

Anopheles quadrimaculatus

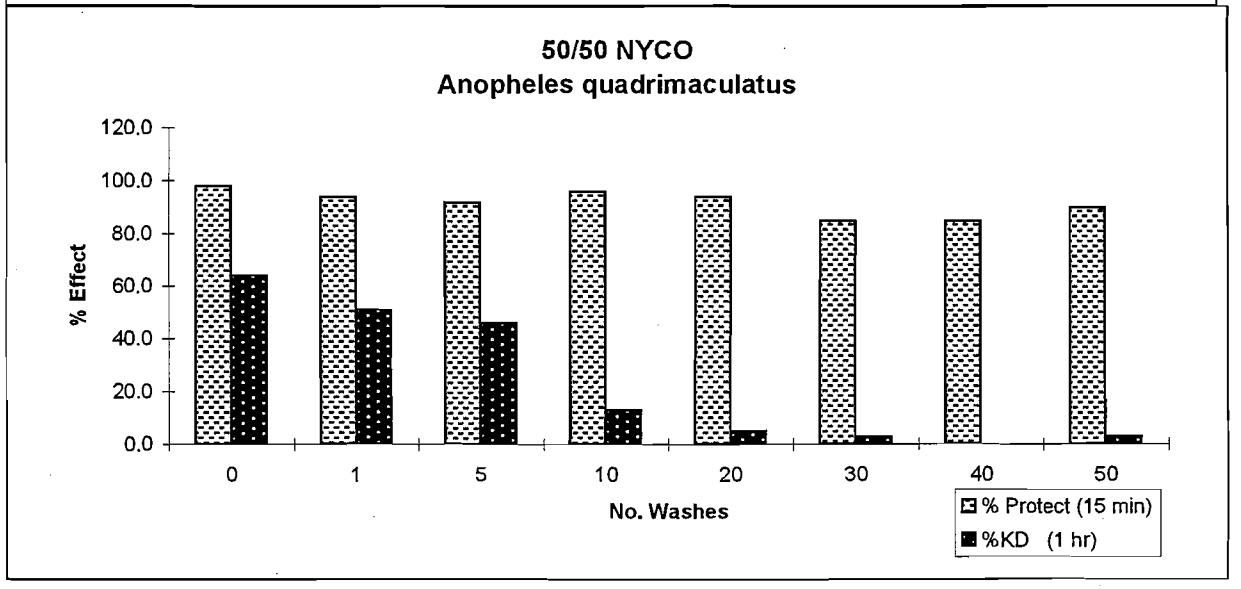
100% Cotton BDU

# Washes	% Protect (15 min)	%KD (1 hr)
0	96.0	54.0
1	98.0	45.0
5	93.0	20.0
10	98.0	9.0
20	78.0	3.0
30	65.0	1.0
40	42.0	1.0
50	38.0	0.0



50/50 NYCO BDU

# Washes	% Protect (15 min)	%KD (1 hr)
0	98.0	64.0
1	94.0	51.0
5	92.0	46.0
10	96.0	13.0
20	94.0	5.0
30	85.0	3.0
40	85.0	0.0
50	90.0	3.0



%Protect = % Protection from Bites

%KD = % Knockdown of Pest

NRDEC: MER 8868, Sep 87

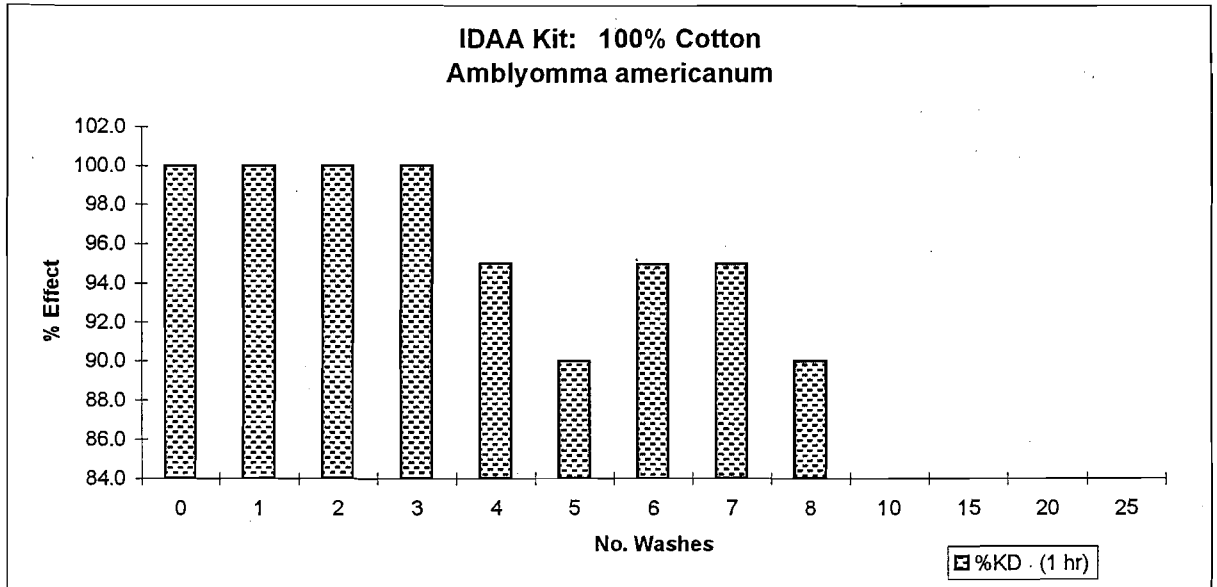
Ticks

Permethrin at 0.125 mg/sq cm; 8 & 25 Washes

Amblyomma americanum

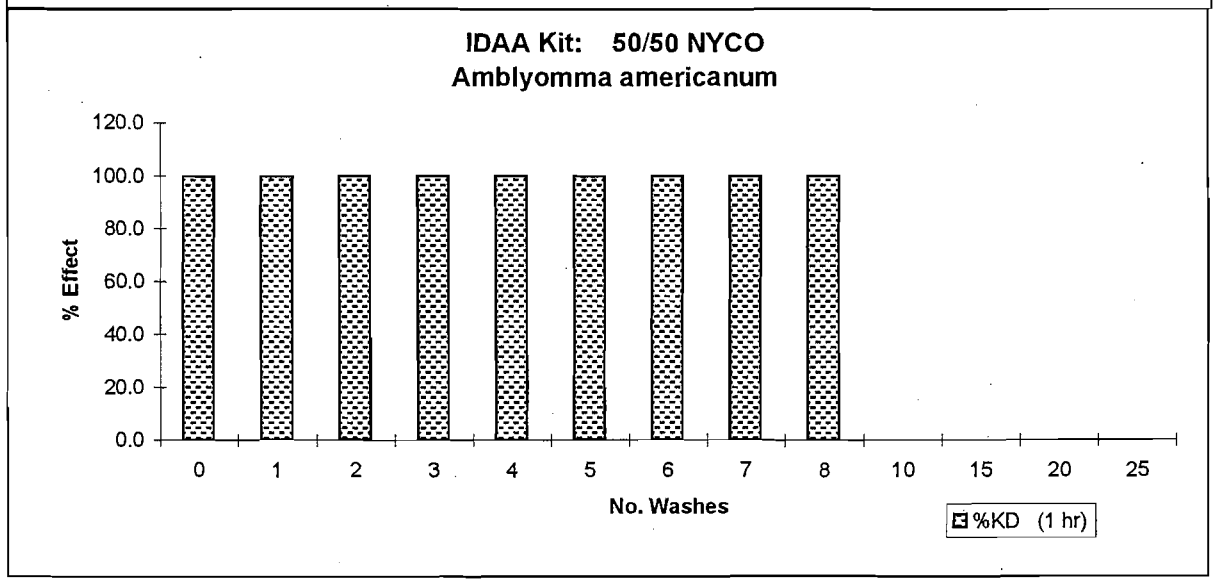
100% Cotton BDU

# Washes	%KD (1 hr)
0	100.0
1	100.0
2	100.0
3	100.0
4	95.0
5	90.0
6	95.0
7	95.0
8	90.0
10	
15	
20	
25	



50/50 NYCO BDU

# Washes	%KD (1 hr)
0	100.0
1	100.0
2	100.0
3	100.0
4	100.0
5	100.0
6	100.0
7	100.0
8	100.0
10	
15	
20	
25	



%KD = % Knockdown of Pest

Final Report to the
U.S.A.M.R.D.C. 1986

USDA Gainesville: 1987

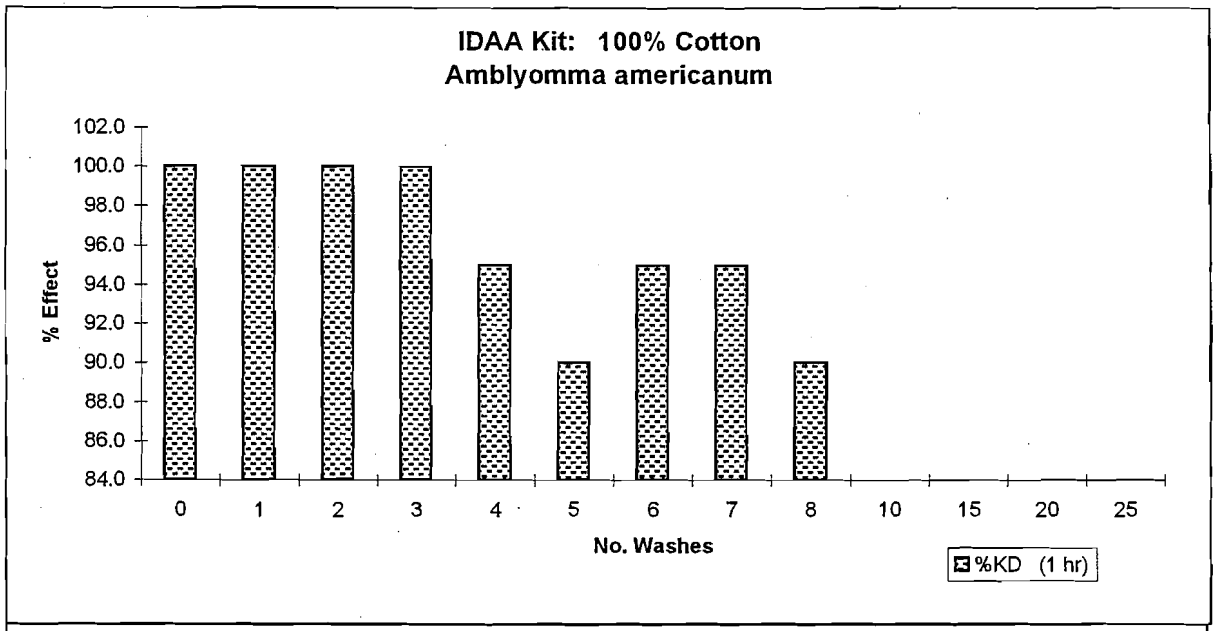
Ticks

Permethrin at 0.125 mg/sq cm; 8 & 25 Washes

Amblyomma americanum

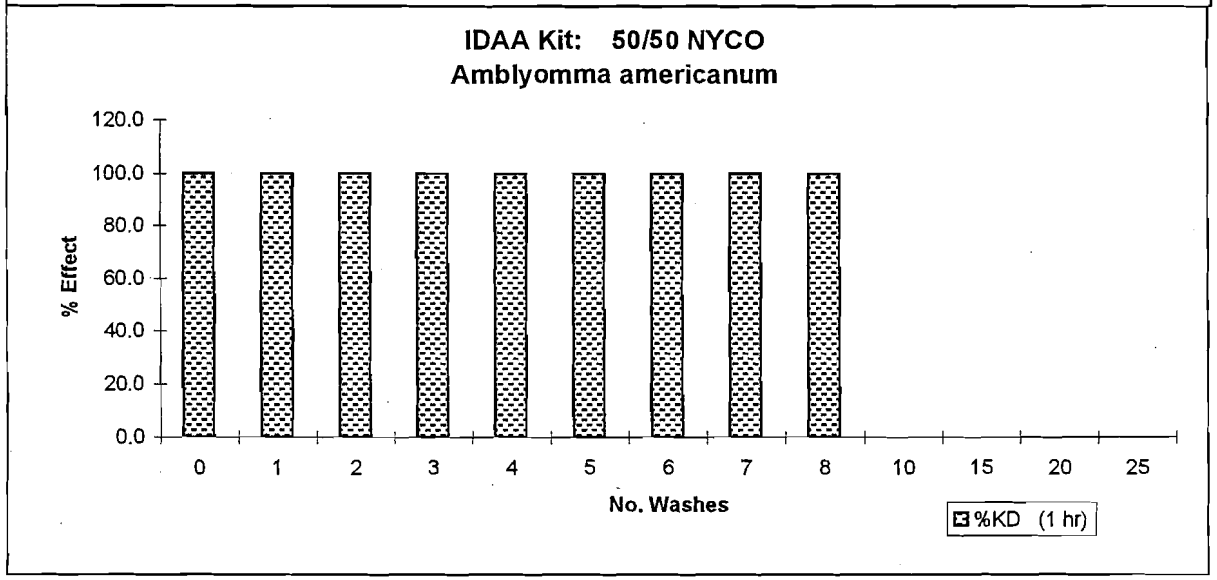
100% Cotton BDU

# Washes	%KD (1 hr)
0	100.0
1	100.0
2	100.0
3	100.0
4	95.0
5	90.0
6	95.0
7	95.0
8	90.0
10	
15	
20	
25	



50/50 NYCO BDU

# Washes	%KD (1 hr)
0	100.0
1	100.0
2	100.0
3	100.0
4	100.0
5	100.0
6	100.0
7	100.0
8	100.0
10	
15	
20	
25	



%KD = % Knockdown of Pest

Final Report from Gainesville to the USAMRDC 1986

USDA Gainesville: 1987

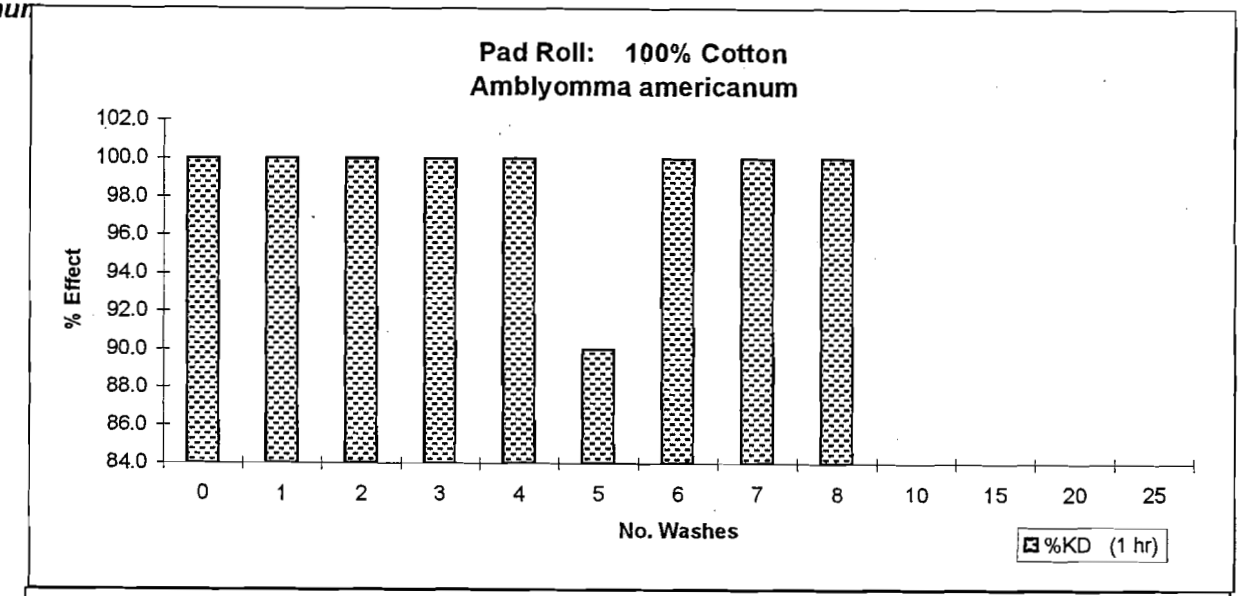
Ticks

Permethrin at 0.125 mg/sq cm; 8 & 25 Washes

Amblyomma americanum

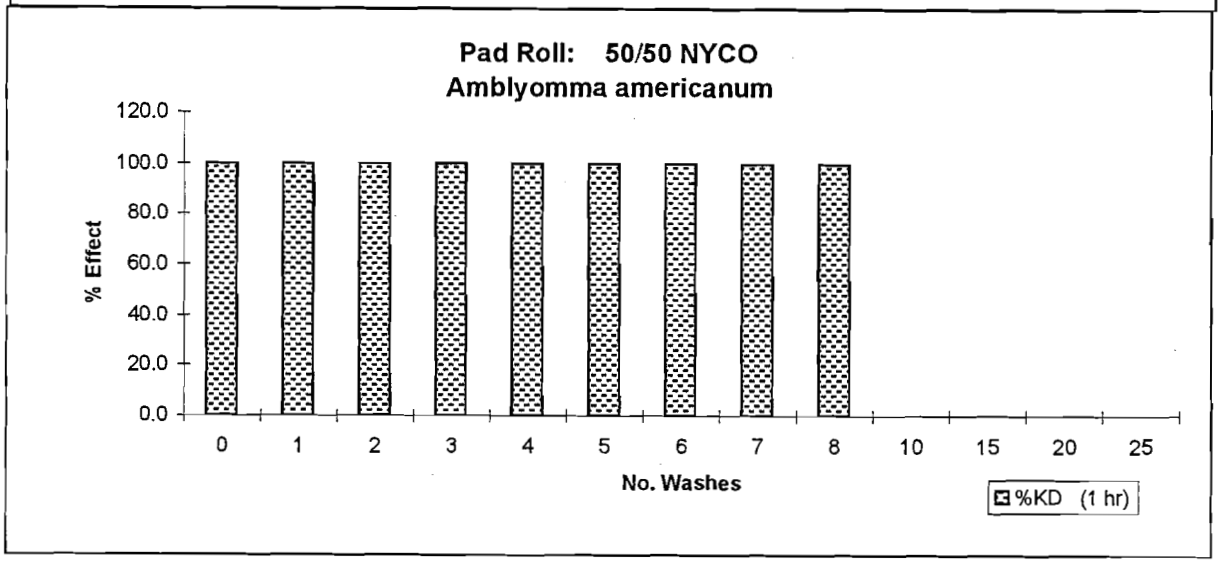
100% Cotton BDU

# Washes	%KD (1 hr)
0	100.0
1	100.0
2	100.0
3	100.0
4	100.0
5	90.0
6	100.0
7	100.0
8	100.0
10	
15	
20	
25	



50/50 NYCO BDU

# Washes	%KD (1 hr)
0	100.0
1	100.0
2	100.0
3	100.0
4	100.0
5	100.0
6	100.0
7	100.0
8	100.0
10	
15	
20	
25	



%KD = % Knockdown of Pest

USDA Gainesville: 1987

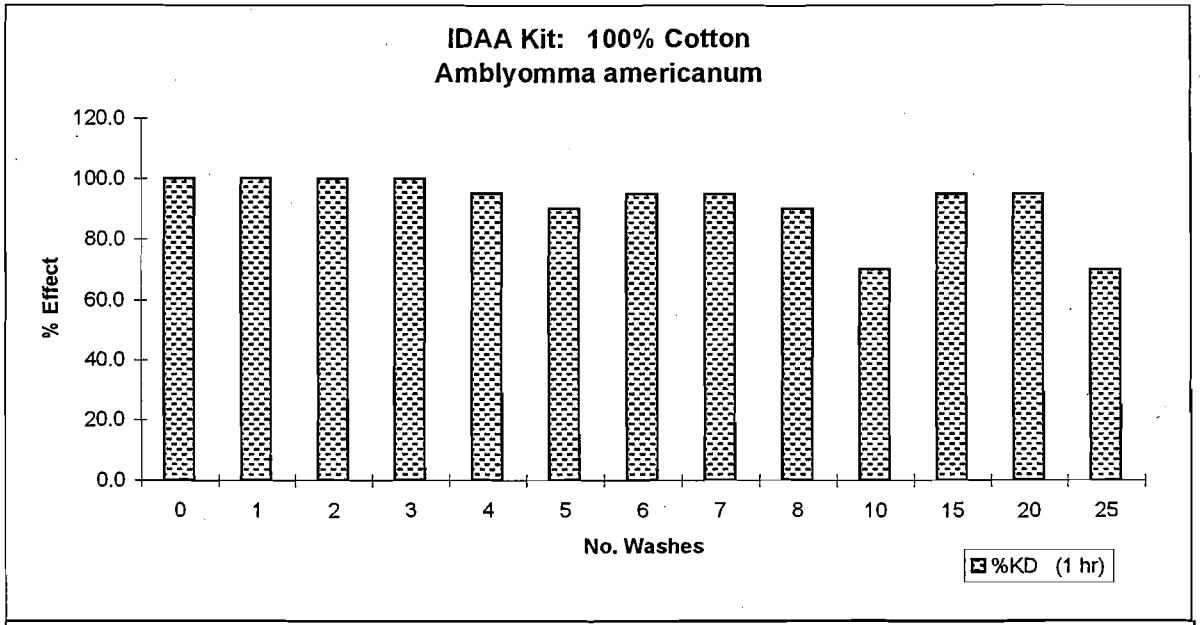
Ticks

Permethrin at 0.125 mg/sq cm; 8 & 25 Washes

Amblyomma americanum

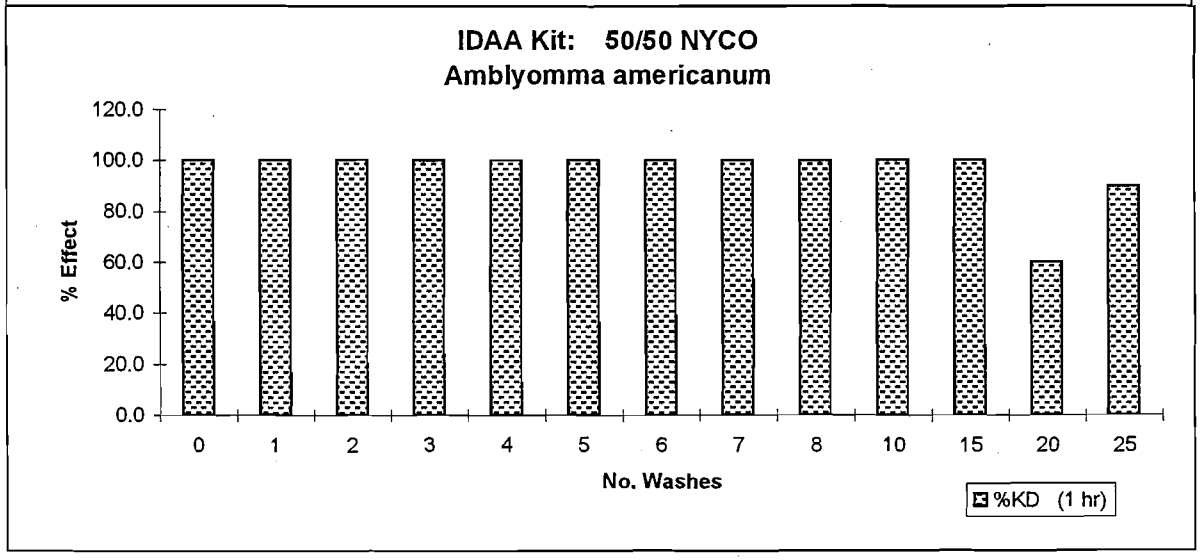
100% Cotton BDU

# Washes	%KD (1 hr)
0	100.0
1	100.0
2	100.0
3	100.0
4	95.0
5	90.0
6	95.0
7	95.0
8	90.0
10	70.0
15	95.0
20	95.0
25	70.0



50/50 NYCO BDU

# Washes	%KD (1 hr)
0	100.0
1	100.0
2	100.0
3	100.0
4	100.0
5	100.0
6	100.0
7	100.0
8	100.0
10	100.0
15	100.0
20	60.0
25	90.0



%KD = % Knockdown of Pest

USDA Gainesville: 1987